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AIRBORNE MEASUREMENTS IN SUPPORT OF A FIELD TEST OF THE STABILI--ETC(U)
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6 AIRBORNE MEASUREMENTS IN SUPPORT OF A FIELD TEST OF THE ~~STABALIZATION~~ stabilization OF SUPERSIZED WATER DROPLETS: PILOT EXPERIMENT.

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ABSTRACT

This report is concerned with

The Navy's ~~has~~ need for screening by particulate matter or fog, for various applications including camouflage and electromagnetic sensing. Certain hygroscopic material such as the Salty Dog effluent can be generated by pyrotechnic devices. These have been found to produce foggy plumes when released in moist stable air. Therefore it is appropriate within the NAVAIR aerosol program to examine meteorological conditions which would influence the formation and dissipation of such plumes.

ABSTRACT

The Bellanca research aircraft operated by Airborne Research Associates is equipped with a variety of meteorological sensors which can detect aerosols and the structural features of the air mass and ocean. These include air temperature, dew point temperature, turbulence, electric fields, small particle mass loading (nephelometer), and the temperature of the land or sea surface beneath the aircraft (infra-red thermometer).

It has been suggested by Dr. Lothar Ruhnke, Head of the Atmospheric Science Section, Naval Research Laboratory, that fogs generated by the Salty Dog pyrotechnic might be prolonged by treating the droplets with a stabalizing agent. This would coat the drop and retard evaporation. In order to test this possibility, a pilot experiment was conducted at Nantucket Island during the summer of 1978 in which untreated Salty Dog plumes were compared with plumes treated with several different alcohol-type stabalizing agents. Naval Research Lab (NRL) personnel generated Salty Dog plumes which were tracked and sampled by the Bellanca aircraft. This aircraft thus supported the NRL group which will issue a complete report describing details of how the aerosol plumes were generated and treated. This report concerns the aircraft measurements. These data have been given to the NRL group (Stuart Gathman) for analysis relative to their other data.

Eight plumes were generated and measured by the ARA aircraft. Time histories were obtained of the scattering coefficient (b_{scat}) by repeated systematic penetrations of the plume as it drifted downwind from the generator. Four plumes were studied on 21 September 1978 and four more were studied on 23 September 1978. Each of the types of droplets described in Table I were represented in the measurements.

Although the two days chosen for the experiment had cloudless skies, they differed dramatically from each other in regard to turbulence. The first day had a strong temperature inversion starting close to the sea surface. The surface wind was 24 knots from a magnetic heading of 243 degrees. The air temperature was 20 degrees C and the relative humidity was 88%. The Barnes PRT-5 radiation thermometer indicated the sand surface was at 23 C while the water surface was 14 C on the Atlantic side of the narrow sand bar (running north-south) where the smoke was generated. Thus the smoke was carried out over the Atlantic by the wind and it remained close to the surface beneath the inversion through its entire lifetime. The stable atmosphere on this day is clearly evident in the temperature profile shown as Figure 1.

On 23 September the wind was from the opposite direction, 083 degrees magnetic at a speed of 11 knots. The air temperature was 16.7 C and the relative humidity was 69%. The radiation thermometer on the aircraft measured the sand temperature as 18 C while the waters in Nantucket Sound overwhich the plume traveled showed a radiation temperature of 13 C. On this day the air was unstable and the plume was seen to rise at an angle of about 10 to 20 degrees from the surface due to convective plumes. This made it harder to fly through and locate. The temperature and relativity profiles obtained from the aircraft just before the experiment are seen in Figure 2.

During the aircraft measurements, the procedure was to fly downwind over the Salty Dog generator as soon as possible after the burn commenced and to

visually keep the aircraft within the plume by flying down its length until it was no longer visible. Simultaneously an observer on the aircraft who was looking at a graphic record of the nephelometer output called out when the aircraft was sensing the plume and when the signal was no longer detectable. At that time the aircraft was turned around and flew back parallel to the outbound path until it was far enough upwind to make another downwind run starting at the generator. Thus an elongated figure eight flight path was followed with the downwind leg within the plume. This procedure was repeated until the plume could no longer be detected visually or with the nephelometer.

Table II describes the details of the various plumes produced in the experiment. Approximately equal masses of Salty Dog material were burned in each test. Likewise, the burn times of all eight tests were approximately equal with an average burn time of 1.3 minutes.

While the external conditions (stability of the atmosphere) differed greatly between the first group (first day) and second group (second day), within each group meteorological conditions remained quite constant during the period when measurements were being made.

The overall result of the experiment was that treated plumes lasted longer than non-treated ones. Three tests stand out in particular, numbers 4,9 and 10. These are precisely the same fogs in which care was taken to grow the droplets formed on the Salty Dog nuclei in greater than ambient humidity to larger sizes and to then stabilize these droplets with a cetyl alcohol monolayer coating in order to slow evaporation.

Figure 3 depicts the overall configuration of Nantucket Island, the sand bar where the Salty Dog generator was located is marked "The Galls". On the first day the plume was carried to the east and on the second day to the west.

Figure 4 shows the dissipation of each plume with time.

Recommendations

Considerably more data is needed to ascertain more quantitatively how effective the treatments are in prolonging the life of water drops. It is recommended that additional tests be conducted from the same site on Nantucket Island which proved to be an ideal location during the pilot experiment. The effects of different treatments and meteorological conditions should be explored. Also it would be important to measure the change in drop size distribution between the different treatments and under varying weather conditions. While this might be done from a boat if the plume stays close to the water surface under a low inversion such as existed on the first day (21 Sept.), it would be much better to have such instrumentation on the aircraft so the plume could be tracked as it rose above the surface. The possibility of installing such equipment, possibly by modifying an atmospheric electrical conductivity device (Gerdien tube), is being discussed with Stuart Gathman and we will try this approach if it seems viable.

TABLE 1

TYPE	SUPERSIZED	STABILIZED	METHOD OF STABILIZATION
1	no	no	
2	no	yes	cetyl alcohol spray
3	yes	no	
4	yes	yes	cetyl alcohol spray
5	yes	yes	"frostop"

TABLE II

PLUME CHARACTERISTICS

Composition	Experiment number	Amount of Salty Dog used (grams)	Elapsed time to last plume detection (minutes)	Estimated time to background level	burn time (minutes)
Salty Dog + H_2O	3	441	3.0	5.2	1.5
Salty Dog + H_2O + Frostop	4	466	8.5	10.5	1.3
Salty Dog + Cetyl Alcohol	5	342	4.5	6.0	1.4
Salty Dog (dry)	6	445	7.0	8.5	1.4
Salty Dog + H_2O	8	482	2.4	4.0	1.4
Salty Dog + H_2O + Frostop	9	427	9.3	12.	1.2
Salty Dog + H_2O + Cetyl Alcohol	10	436	9.6	11.3	1.6
Salty Dog (dry)	11	452	7.0	7.5	1.4

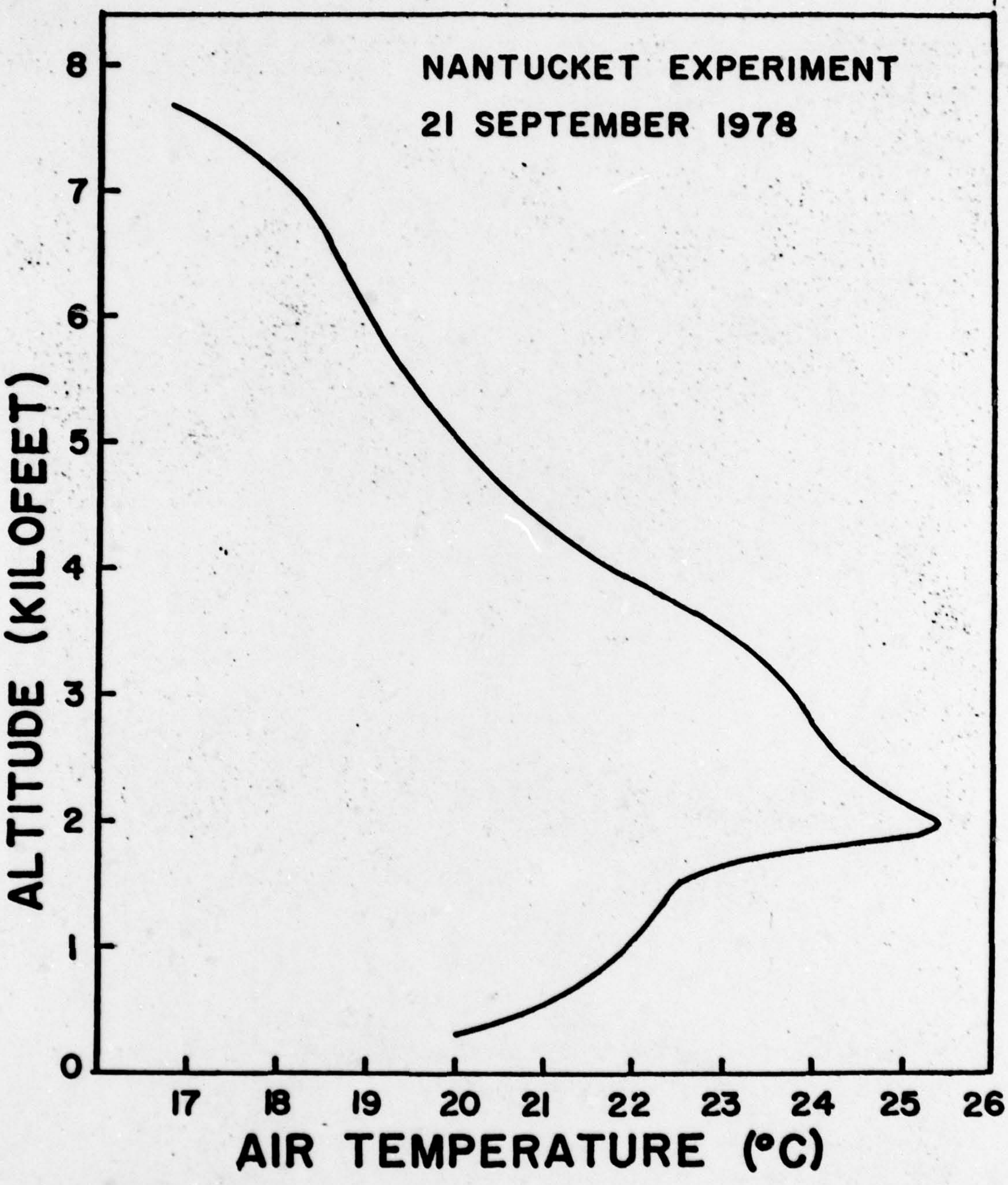


FIG. 1 TEMPERATURE PROFILE

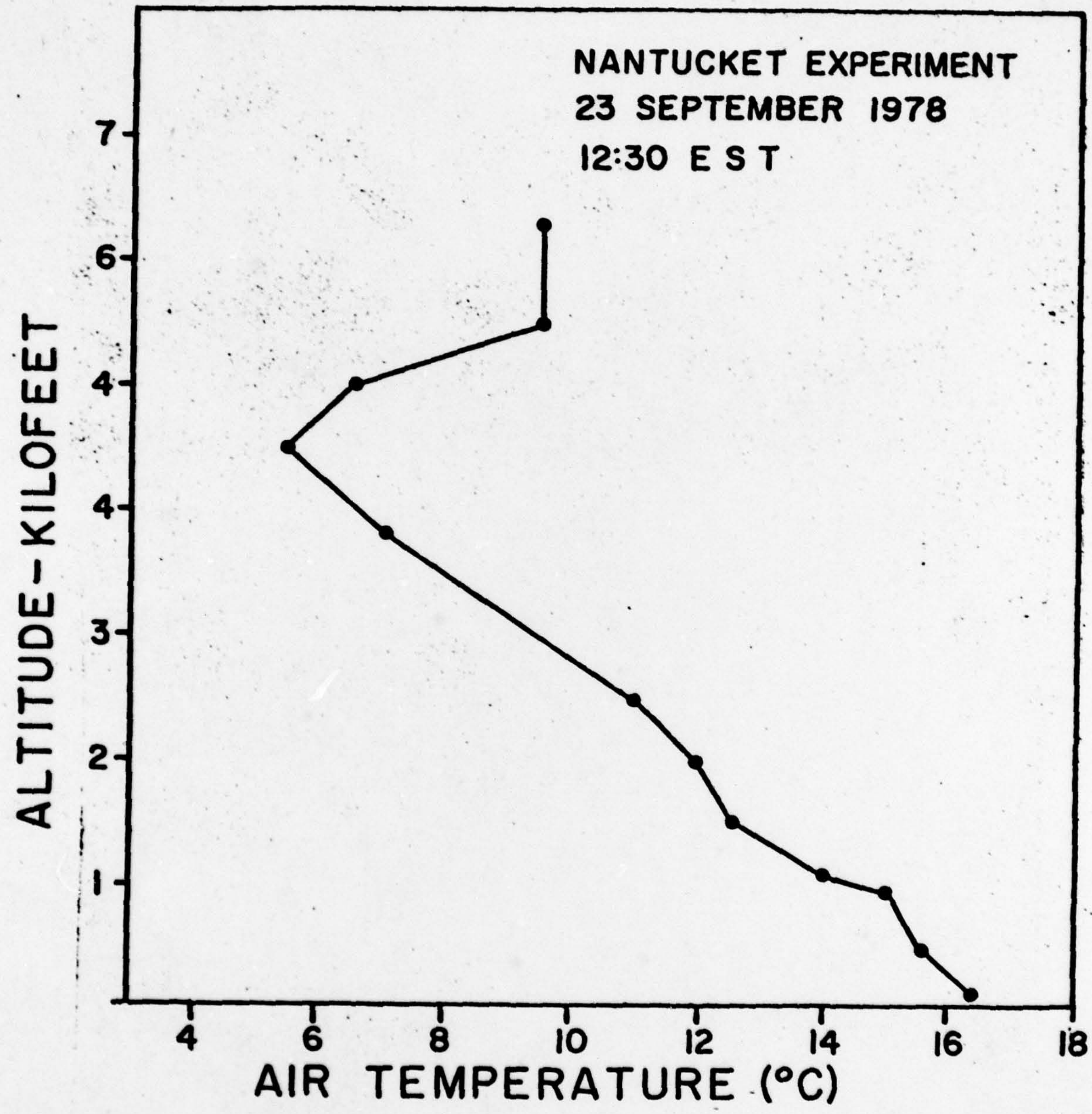


FIG. 2a TEMPERATURE PROFILE

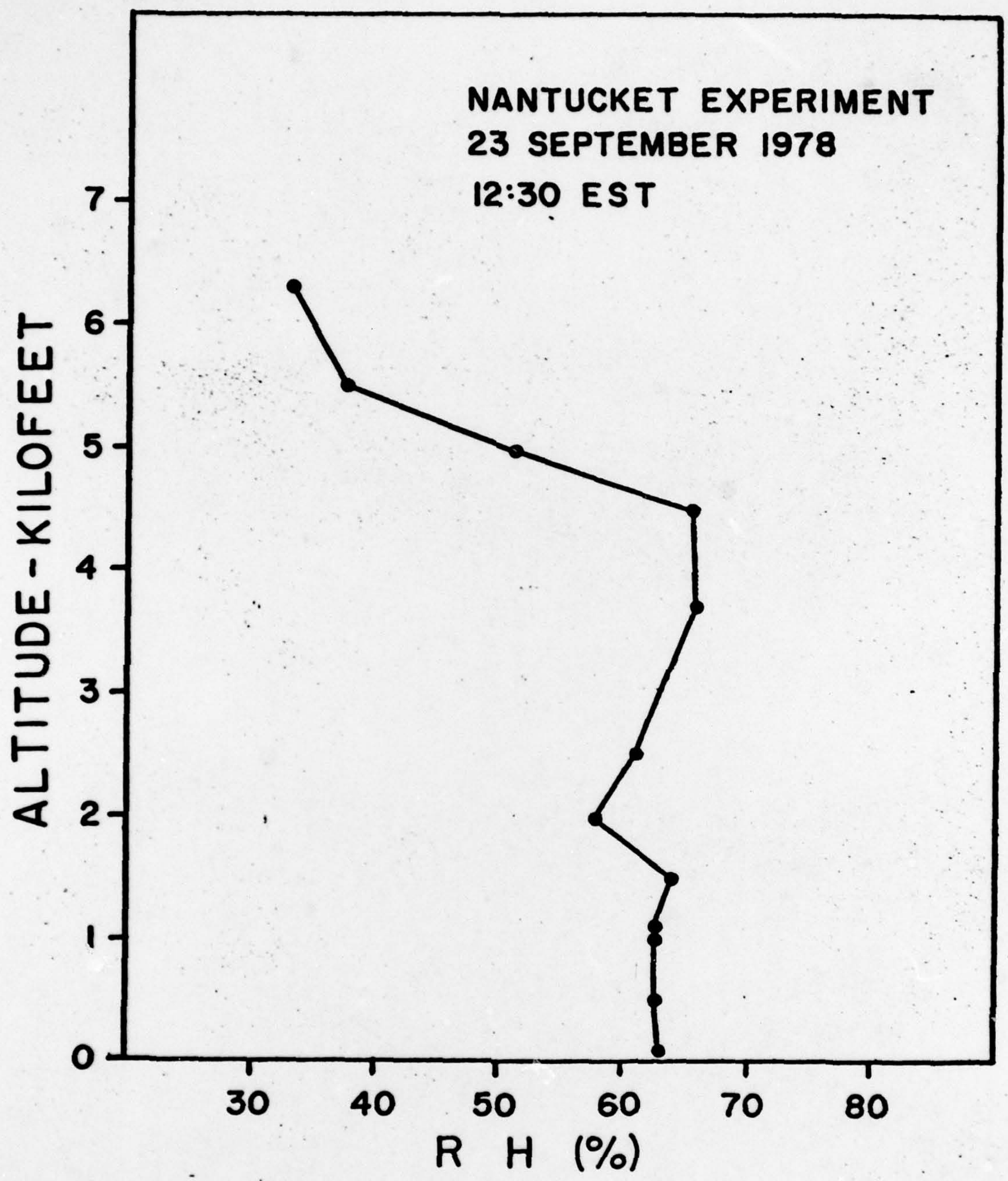
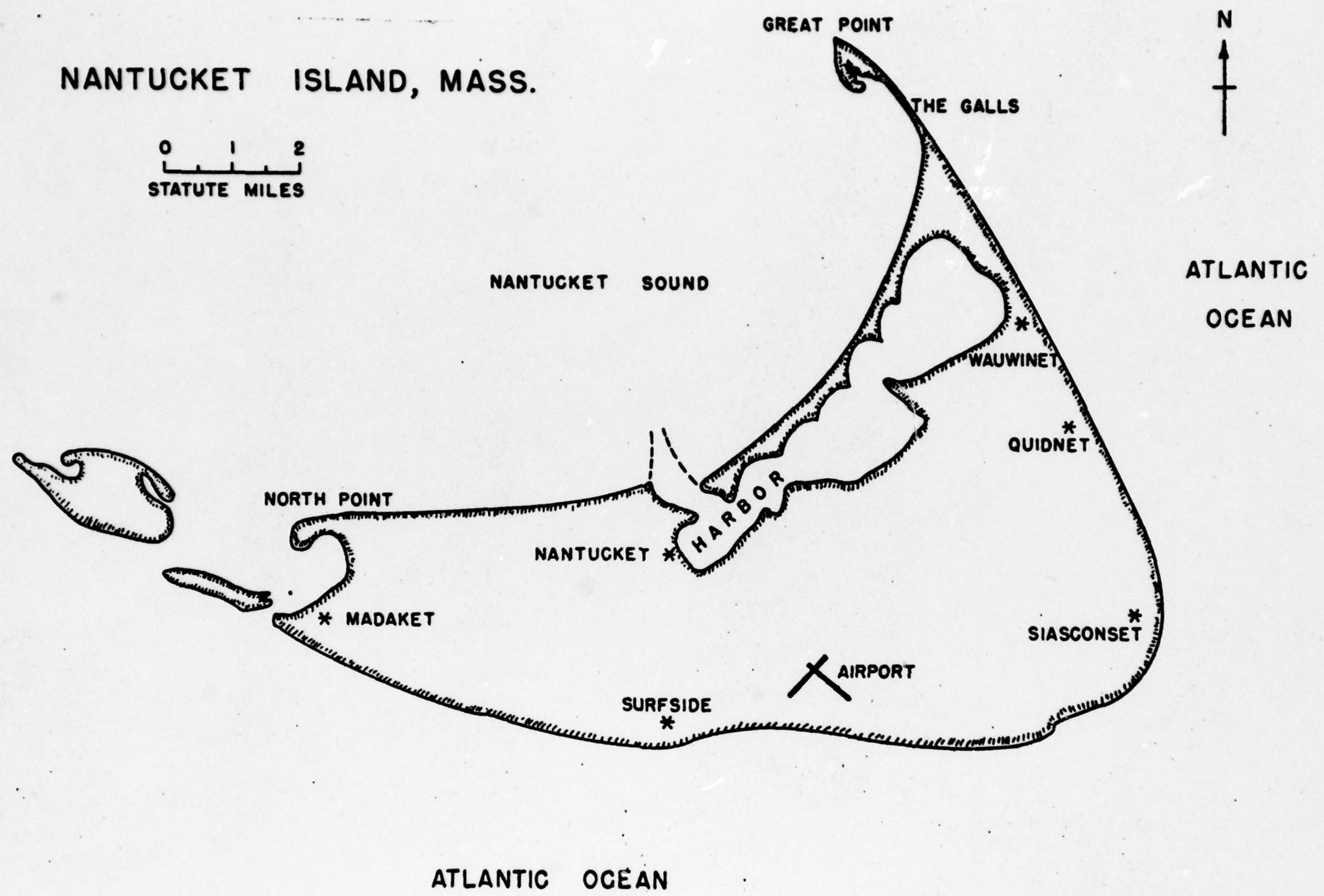


FIG. 2b RELATIVE HUMIDITY PROFILE



NANTUCKET ISLAND, MASS.
0 1 2
STATUTE MILES
N
GREAT POINT
THE GALLS
ATLANTIC
OCEAN
NANTUCKET SOUND
WAUWINET
QUIDNET
HARBOR
NORTH POINT
NANTUCKET
MADAKET
SIASCONSET
AIRPORT
SURFSIDE
ATLANTIC OCEAN

FIG. 3

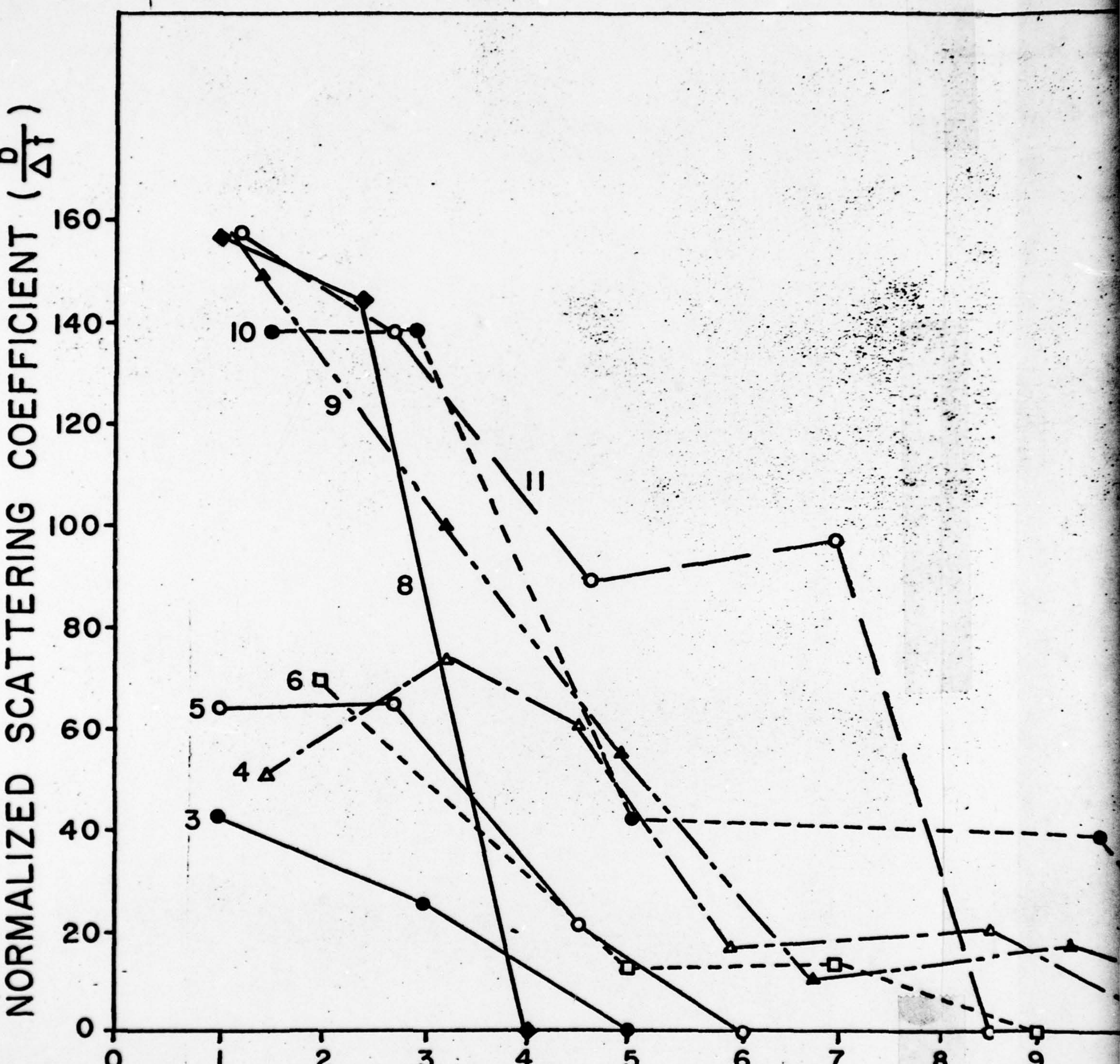


FIG.4 EXPERIMENTAL PLUME OBSERVATION

PLUME OBSERVATION

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